PTO 04-4812

CY=JA DATE=19910520 KIND=A
PN=03-117277

AUTOFOCUS CAMERA
[Oto Fokasu Kamera]

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UNITED STATES PATENT AND TRADEMARK OFFICE
Washington, D.C. August 2004

Translated by: FLS, Inc.

PUBLICATION COUNTRY	(19):	JP
DOCUMENT NUMBER	(11):	03117277
DOCUMENT KIND	(12):	A
	(13):	PUBLISHED UNEXAMINED APPLICATION (Kokai)
PUBLICATION DATE	(43):	19910520
PUBLICATION DATE	(45):	
APPLICATION NUMBER	(21):	01255700
APPLICATION DATE	(22):	19890929
ADDITION TO	(61):	
INTERNATIONAL CLASSIFICATION	(51):	H04N 5/232
DOMESTIC CLASSIFICATION	(52):	
PRIORITY COUNTRY	(33):	
PRIORITY NUMBER	(31):	
PRIORITY DATE	(32):	
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APPLICANT	(71):	SANYO ELECTRIC CO., LTD.
TITLE	(54):	AUTOFOCUS CAMERA
FOREIGN TITLE	[54A]:	Oto Fokasu Kamera

SPECIFICATION /537*

1. Title

AUTOFOCUS CAMERA

2. Claims

(1) An autofocus camera equipped with

an integrating means that integrates over the period of one field the high-frequency components of luminance signals obtained by an imaging device,

a relative lens-position changing means that changes the lens position relative to the aforesaid imaging device,

a separating means that separates the integrated output of the (3n+1)th, (3n+2)th, and (3n)th (n being an integer) fields, counting from the start of the integration, into the first to third focus evaluation values, and

first to third position memories that store, as the first to third focusing positions, the relative lens positions at which are obtained the largest first to third focus evaluation values,

said camera holding the aforesaid relative lens position at the focus position obtained based on the aforesaid first through third focusing positions.

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* Number in the margin indicates pagination in the foreign text.

3. Detailed Description of the Invention

(A) Industrial Application of the Invention

The present invention pertains to the autofocusing device of a camera that carries out automatic focus matching based on luminance signals in image video signals obtained from an imaging device.

(B) Prior Art

With respect to the autofocusing device of a camera, a focus control approach utilizing the high-frequency components of image signals per se obtained from the imaging device for focus control evaluation has various advantageous points--for example, there is essentially no parallax, and objects with a shallow depth of field or distant objects can also be focused with good accuracy. In addition, this approach does not require a special sensor for autofocusing use, and, as such, it is also quite simple structurally.

In JP-A-S63-125910 (G02B7/11) is disclosed one example of what is called the hill-climbing autofocus system described in the foregoing. The following explains the essential feature of this prior technique, referring to Figs. 2 and 3. Fig. 2 is a block diagram of the entire circuitry of the prior technology. In this figure, an image formed by the lens (1) is converted into a video signal by the imaging circuit (4) containing an imaging device and input to the focus-evaluation- /538 value generating circuit (5). The focus-evaluation-value generating circuit (5) is configured as shown in Fig. 3. The video signal is

separated into a vertical synchronizing signal (VD) and horizontal synchronizing signal (HD) by the synchronizing separator circuit (5a), which signals are then input to the gate control circuit (5b) so as to set a sampling area as the focus area. The gate control circuit (5b) sets a rectangular sampling area at the center of the screen based on the vertical synchronizing signal (VD), horizontal synchronizing signal (HD), and a fixed oscillator output that drives the imaging device, and the gate control circuit supplies the gate circuit (5c) with a gate-open/close signal that only allows a luminance signal that is within the range of this sampling area to pass.

Owing to the function of the gate circuit (5c), a luminance signal within the range of the focusing area alone passes through a high-pass filter (H.P.F.) (5d), thus separating the high-frequency component alone, which then undergoes amplitude detection in the subsequent detection circuit (5e). This detection output is converted into a digital value by the A/D (analog-to-digital) conversion circuit (5f) at a given sampling cycle and input to the integrator (5g) sequentially.

This integrator (5g), in concrete terms, is what is called a digital integrator that is comprised of an adder for adding the A/D converted data and the latch data of the subsequent latch circuit and also comprised of this latch circuit that latches this added value and that is reset field by field, and the sum of all the A/D converted data from the period of one field is output as the focus evaluation

value. That is to say, the focus-evaluation-value generating circuit extracts luminance signals in the focus area in a time dividing manner, then digitally integrates the high frequency components thereof over the period of one field, and outputs the resulting integrated value as the focus evaluation value of the current field.

Immediately after the automatic focusing operation is initiated, the initial focus evaluation value is stored in the greatest value memory (6) and the initial value memory (7). Thereafter, the focusing motor control circuit (10) causes the focusing motor (3), which moves the lens (1) back and forth via the focus ring (2) along the axis of lens, to rotate in the predetermined direction and monitors the outputs of the second comparator (9). The second comparator (9) compares the focus evaluation value obtained after the focusing motor is operated with the initial evaluation value held in the initial value memory (7) and outputs a signal indicating whether it is larger or smaller than the initial evaluation value.

The focusing motor control circuit (10) continues to rotate the focusing motor (3) in the direction in which it has been moving until the second comparator (9) outputs a signal indicating that the focus evaluation value is larger or smaller. If the second comparator (9) outputs a signal indicating that the current focus evaluation value is larger than the initial focus evaluation value by a degree that exceeds the preset fluctuation margin, the focusing motor control circuit (10) maintains the current rotation direction. On the other

hand, if it outputs a signal indicating that the current focus evaluation value is smaller than the initial focus evaluation value by a degree that exceeds the aforesaid fluctuation margin, the focusing motor control circuit (10) reverses the rotation direction of the focusing motor (3) and starts monitoring the outputs of the first comparator (8).

The first comparator (8) compares the greatest value among the focus evaluation values held so far in the greatest value memory (6) with the current focus evaluation value and outputs two kinds of H-level comparison signals (P1, P2), that is, a signal indicating that the current focus evaluation value is greater than the content of the greatest value memory (6) (the first mode) and another indicating that the current focus evaluation value is smaller by a degree that exceeds the aforesaid first preset threshold (the second mode). Here, based on the output of the first comparator (8), the greatest value memory (6) updates the value it holds if the current focus evaluation value is greater than the content of the greatest value memory (6), thereby always holding the greatest value among the focus evaluation values so far obtained.

Reference numeral 13 indicates a focus-ring-position memory that receives the focus-ring-position signal that designates the position of the focus ring (2) that supports the lens (1) and stores the position of the focus ring as the position of the lens, and this memory, like the greatest value memory (6), is updated based on the

output of the first comparator (8) so as to always hold the lens position at which the greatest evaluation value was obtained. Here, it is a well-known technology to rotate the focus ring (2) by the focusing motor (3) and to move the lens (1) back and forth along the axis of lens by this rotation. Incidentally, focus-ring position signals are generally output from a potentiometer provided to detect the focus-ring position. However, it is also possible to utilize a stepping motor as the focusing motor (3) and to detect the amount of rotation of this motor in the near-point direction or the infinity-point direction as a positive or negative stepping amount, thereby expressing the focus-ring position or focusing motor position by this stepping amount.

The focusing motor control circuit (10) monitors the outputs of the first comparator (8) while rotating the focusing motor (3) in the /539 direction that has been determined based on the output of the second comparator (9), and, in order to prevent false operations from occurring due to noises in the evaluation values, the control circuit reverses the rotation direction of the focusing motor (3) as soon as the first comparator (8) outputs a signal indicating the second mode, that is, a signal indicating that the current evaluation value is smaller than the greatest evaluation value by a degree that exceeds the first threshold (Δy) (that is to say, as soon as the value has reached Q in Fig. 4). After the focusing motor (3) is thus reversed, the third comparator (14) compares the content of the position memory

(13) and the current focus-ring position signal. When they match, that is to say, when the lens (1) has returned to the position (P) that yields the greatest focus evaluation value, the focusing motor control circuit (10) stops the focusing motor (3). At the same time, the focusing motor control circuit (10) outputs a lens stop signal (LS), thereby completing the focusing operation.

Reference signal 11 indicates a fourth memory that holds the focus evaluation value obtained at the moment at which the focus motor control circuit (10) has completed the focusing operation and issued a lens stop signal (LS). The subsequent fourth comparator (12) compares the content held by this fourth memory (11) with the current focus evaluation value, and, when the current focus evaluation value exceeds the second threshold value used for restarting, it outputs a subject-change signal to the focusing motor control circuit (10), assuming that there is a change in the photographic subject. Upon receiving this signal, the focusing motor control circuit (10) starts over the focusing operation to follow the change of the subject.

(C) Problems that the Invention Intends to Solve

The prior-art system described in the foregoing has extremely high followability and also has high focusing accuracy. However, if the luminance of the photographic subject fluctuates at a specific frequency that is different from the frequency of one field of video signals, this luminance fluctuation could cause false operations. The following explains this situation in somewhat more detail.

For example, with a video camera of the NTSC system, the frequency of one field is 60 Hz, and the aforesaid type of false operation occurs when this camera is used under the lighting of a discharge lamp, such as a fluorescent lamp, etc. Because the luminance of a discharge lamp lighting at 50 Hz fluctuates at a frequency of 100 Hz, the luminance of the photographic subject also fluctuates at a frequency of 100 Hz. Since the frequency of one field of video signals is 60 Hz, a ripple of 20 Hz, the beat frequency of these frequencies, occurs.

More specifically, the average luminance level of each field in the case of photographing a given subject under a lighting having a constant illuminance is usually maintained at a constant value, as shown in Fig. 5 (a). However, as mentioned in the foregoing, flickering occurs under the lighting of a 50 Hz discharge lamp, and, as shown in Fig. 5 (b), the luminance level fluctuates from (M1) to (M2) to (M3) to (M1)... in cycles of three fields. The aforesaid average luminance level, similar to the average luminance level of the focus evaluation values in the prior art described before, has the characteristic of changing in proportion to the quantity of the light entering the imaging device even if the distance to the subject stays the same and also even if the subject itself does not change. Consequently, if there is flickering, as shown in Fig. 5 (b), the focus evaluation value fluctuates in spite of the fact that the same subject distance is maintained and the same subject is photographed.

If a focusing operation is carried out according to the prior art based on this focus evaluation value that is affected by flickering, the peak of the focusing position could be detected erroneously, or, although there is no change in the photographic object, the focusing operation could be restarted unnecessarily, assuming that the greatest value of focus evaluation values has changed.

(D) Means of Solving the Problems

The present invention pertains to an autofocus camera equipped with an integrating means that integrates over the period of one field the high-frequency components of luminance signals obtained by an imaging device, a relative lens-position changing means that changes the lens position relative to the aforesaid imaging device, a separating means that separates the integrated output of the (3n+1)th, (3n+2)th, and (3n)th (n being an integer) fields, counting from the start of the integration, into the first to third focus evaluation values, and first to third position memories that store, as the first to third focusing positions, the relative lens positions at which are obtained the largest first to third focus evaluation values, said camera holding the relative lens position at the average position of the first through third focusing positions.

(E) Operation

Because the present invention is configured as described in the foregoing, even if a 50 Hz discharge lamp causes flickering, its effect on the focusing operation can be suppressed to a minimum.

(F) Embodiment /540

An example embodying the present invention is described in the following, referring to figures.

Fig. 1 is a block diagram of the entire circuitry of the apparatus of the present embodiment. In this Fig. 1, parts that are the same as those in Fig. 2 illustrating the prior art are designated by the same reference symbols, and their explanations are omitted.

The luminance signals in image video signals from the imaging circuit (4) are input to the focus-evaluation-value generating circuit (5), and, as in the prior-art example, the high-frequency components of the luminance signals within the focus area located at the center of the screen are digitally integrated over the period of one field, and this integrated value is output as the focus evaluation value of the current field.

Reference numeral **20** indicates a switch circuit that has a traveling contact piece (20d) that switches field by field from fixed contact **20a** to **20b** to **20c** to **20a** and so forth. Because, in its initial state, it is located at fixed contact **20a**, a focusing operation is initiated, and the focus evaluation value of the first field issued from the focus-evaluation-value generating circuit (5) is output to fixed contact **20a**, the focus evaluation value of the second field to fixed contact **20b**, and the focus evaluation value of the third field to fixed contact **20c**, after which the same procedures are repeated. As a result, fixed contact **20a** receives the focus evaluation value of the

(3n+1)th field (n being an integer) of every three fields, fixed contact **20b** receives the focus evaluation value of the (3n+2)th field pf every three fields, and fixed contact **20c** receives the focus evaluation value of the (3n)th field of every three fields.

The focus evaluation value input to fixed contact **20a** is sent, as the first focus evaluation value (F1), to the subsequent initial value memory (7), the second comparator (9), and the first focusing-position detecting circuit (21). The focus evaluation values input to fixed contacts **20b** and **20c** are sent, as the second and third focus evaluation values (F2 and F3), to the second and third focusing-position detecting circuits (31 and 41).

The initial value memory (7) holds the initial value of the first focus evaluation value, that is, the focus evaluation value obtained immediately after the start of the focusing operation, and the second comparator (9) compares the initial focus evaluation value held in this initial value memory (7) with a first focus evaluation value (F1) obtained thereafter and outputs a signal indicating whether it is larger or smaller than the initial evaluation value.

The focusing motor control circuit (50), like the one in the prior-art example, continues to rotate the focusing motor (3) in the predetermined initial direction until the second comparator (9) issues a signal indicating that the focus evaluation value is larger or smaller. If the second comparator (9) outputs a signal indicating that the current first focus evaluation value is larger than the initial

focus evaluation value by a degree that exceeds the preset fluctuation margin, the focusing motor control circuit (50) maintains the current rotation direction, while, if it outputs a signal indicating that the current focus evaluation value is smaller by a degree that exceeds the aforesaid fluctuation margin, the focusing motor control circuit (50) reverses the rotating direction of the focusing motor (3). In this manner, the focusing motor control circuit (50) determines the rotation direction of the focusing motor (3).

After the rotation direction is determined, the first through third focusing-position detecting circuits (21, 31, and 41) each detect the focus-ring position, that is, the lens position, at which the first to third focus evaluation values become the greatest values and output these as the first to third focusing-position data (D1, D2, and D3).

The first focusing-position detecting circuit (21) is comprised of a greatest value memory (26), a comparator (28), and position memory (23). As in the prior-art example, the greatest value memory (26) holds the greatest value among the first focus evaluation values (F1) based on the comparison signal (P1) generated by the comparator (28), and the position memory (23) stores the lens position at which the greatest value held in the greatest value memory (26) can be obtained. The comparator (28) constantly compares the content of the greatest value memory (26) and a first focus evaluation value (F1) and issues comparison signal **P1** when it determines that the latest first

focus evaluation value is greater than the greatest value data stored in the greatest value memory (26), while it issues **P2** when it determines that the first focus evaluation value has decreased by the first threshold value (Δy) compared with the greatest value data. Consequently, the lens position in the position memory (23) obtained when the H-level comparison signal (P2) is issued becomes the first focusing position (G1) that yields the greatest first evaluation value, and the first focusing position data (D1) indicating this position is output.

The second and third focusing-position detecting circuits (31, 41) are also each comprised of a greatest value memory (36, 46), comparator (38, 48), and position memory (33, 43). The comparators (38, 48) output comparison signal **P1** every time the second and third focus evaluation values become the largest and comparison signal **P2** when the comparators find a drop from each greatest value by the first threshold value (Δy). Each greatest value memory and position memory are updated every time comparison signal **P1** is issued, and the lens positions in the position memories (33, 43) obtained when the comparison signal (P2) becomes the H level become the second and third focusing positions (G2, G3) that yield the greatest second and third /541 focus evaluation values, and the second focusing position data and third focusing position data (D2, D3) indicating these positions are output.

The focusing-position determining circuit (51) has the function of selecting, based on the first to third focusing position data (D1, D2, D3), the middle position among the first to third focusing positions (G1, G2, G3) corresponding to each position data as the final focusing position (J). With the example shown in Fig. 6, for example, the relationship G2< G3< G1 holds true; therefore, the third focusing position (G3) is selected as the final focusing position (J).

Three comparison signals (P2) output from the comparators (28, 38, 48) are all input to the AND gate (52), and the output of this AND gate is further input to the focusing control circuit (50). When all of the comparison signals (P2) reach the H level, that is to say, when all of the first to third focus evaluation values have decreased from their own greatest values by the first threshold value (Δy), the AND gate (52) issues an H-level output, and, upon receiving this output, the focusing motor control circuit (50) reverses the focusing motor (3) immediately.

After this reversing of the motor, the third comparator (14) compares the current lens position and the final focusing position (J) and issues an output when these positions match, in other words, when the lens position has returned to the final focusing position (J) after the reversing of the focusing motor (3).

Upon receiving this output, the focusing motor control circuit (50) issues a lens stop signal (LS), considering that the lens has

reached the focusing state, and causes the focusing motor (50) to stop, thereby completing a series of focusing procedures.

Fig. 6 is a graph illustrating changes in the first through third focus evaluation values in relation to the lens position. Each curve represents changes in one of the first through third focus evaluation values (F1, F2, F3) in relation to the lens position. Each point represented by "O" indicates one of the first through third focus evaluation values actually obtained field by field after taking into consideration the lens position change over the period of one field that occurs as the focusing motor (3) is driven, and the distance (L) between two points corresponds to the distance that the lens (1) travels in the period of one field as a result of the driving of the focusing motor (3). Incidentally, to simplify the explanation, the reversing of the focusing motor that is implemented as a drop by the first threshold value (Δy) takes place is not taken into account in Fig. 6, and changes of the focus evaluation values in the entire range, from the near point to the infinity point, are shown here.

With respect to the checking of a change in the photographic subject after the completion of a series of focusing procedures, the following procedure is carried out. After a lens stop signal (LS) is generated, the latest first to third focus evaluation values and the contents of the greatest value memories (26, 36, 46) are constantly compared, utilizing the comparators (23, 38, 48) for the purpose of subject-change checking, and the focusing motor control circuit (50)

monitors these comparison outputs. When any of the first to third focus evaluation values fluctuates more than the predetermined second threshold value, the focusing motor control circuit (50), considering that the photographic subject has moved or changed, resets all the memories and restarts the focusing motor (3), thus restarting the aforesaid focusing operation.

In the aforesaid embodiment, the focusing motor (3) is controlled and driven based on the instruction of the focusing motor control circuit (50) and moves the lens (1) back and forth along the axis of lens, thereby changing the position of the lens relative to the imaging device. In place of this configuration, it is possible to fix the lens itself and move the imaging device back and forth along the axis of lens using a bimorph or motor based on the instruction of the focusing motor control circuit (50). Furthermore, when determining the final focusing position (J), the focusing position determining circuit (51) simply selected the middle position among the first through third focusing positions (G1, G2, G3). In place of this, it is possible to calculate the average position of the three focusing positions.

(G) Effects of the Invention

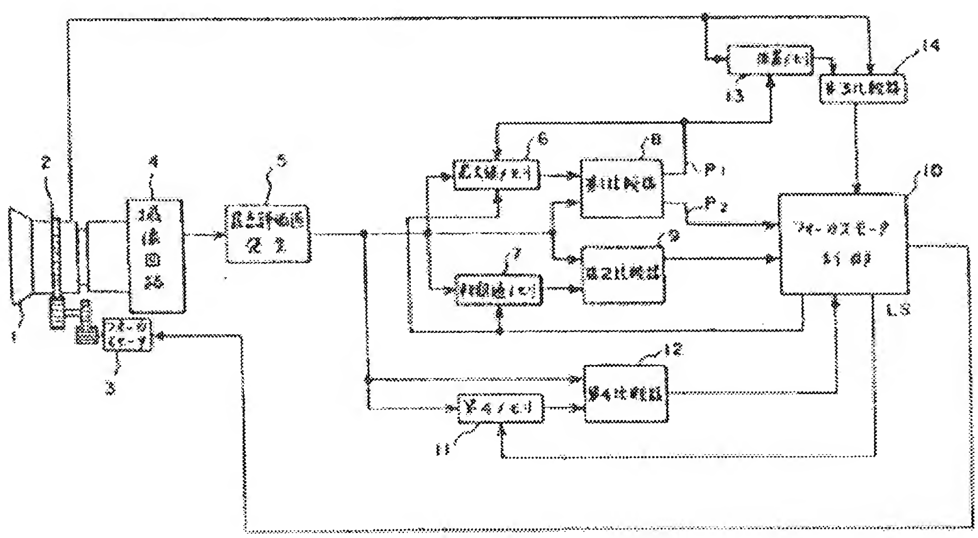
As explained in the foregoing, even under the lighting with a 50 Hz discharge lamp, etc., the present invention makes it possible to prevent a false focusing operation caused by the adverse effect of flickering.

4. Brief Explanation of the Drawings

Fig. 1 is a block diagram of the circuitry of the embodiment of the present invention. Fig. 6 is a graph illustrating changes in the focus evaluation values in the present embodiment. Fig. 2 is a block diagram of the circuitry of the prior-art example, and Fig. 3 is a block diagram of the circuitry of the essential parts thereof. Fig. 4 is an explanatory drawing that illustrates the hill-climbing autofocusing principle. Fig. 5 is a drawing for explaining luminance level fluctuation caused by flickering. /542

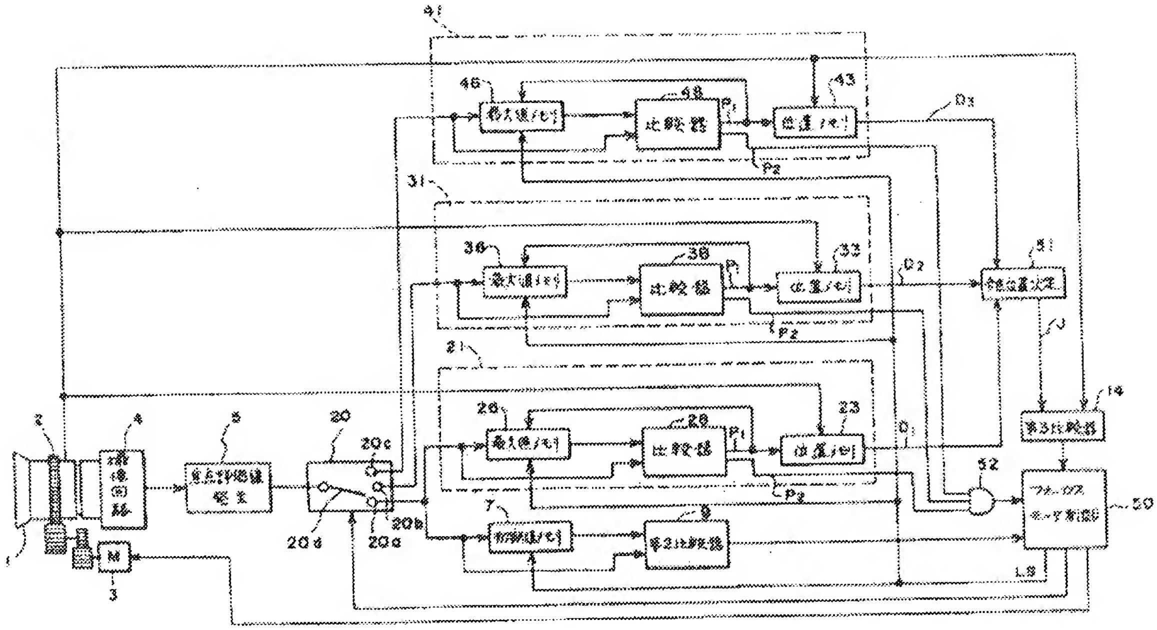
(5) focus-evaluation-value generating circuit, (3) focusing motor, (20) switch circuit, (23, 33, 43) position memories.

FIG. 2



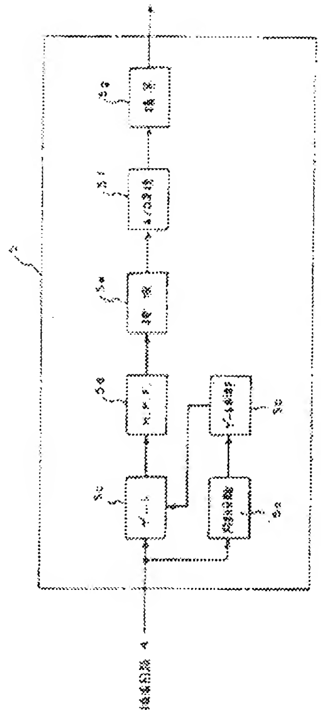
Key: 3) focusing motor; 4) imaging circuit; 5) focus evaluation value generating; 6) greatest value memory; 7) initial value memory; 8) first comparator; 9) second comparator; 10) focusing motor control; 11) fourth memory; 12) fourth comparator; 13) position memory; 14) third comparator.

FIG. 1

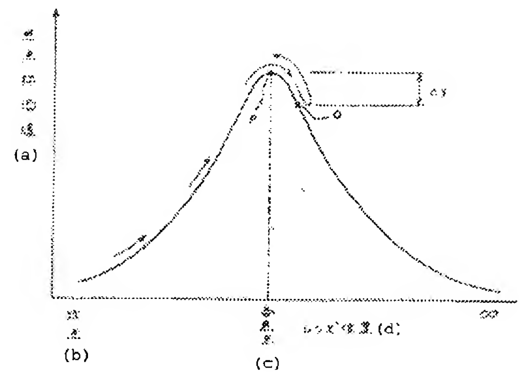


Key: 23, 33, 43) position memory; 4) imaging circuit; 5) focus evaluation value generating; 26, 36, 46) greatest value memory; 7) initial value memory; 28, 38, 48) comparator; 9) second comparator; 14) third comparator; 50) focusing motor control; 51) focusing position determining.

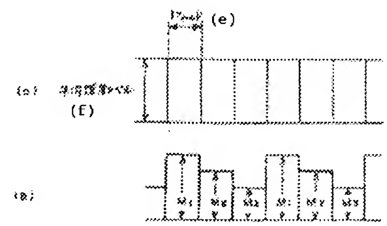
[FIG. 3]



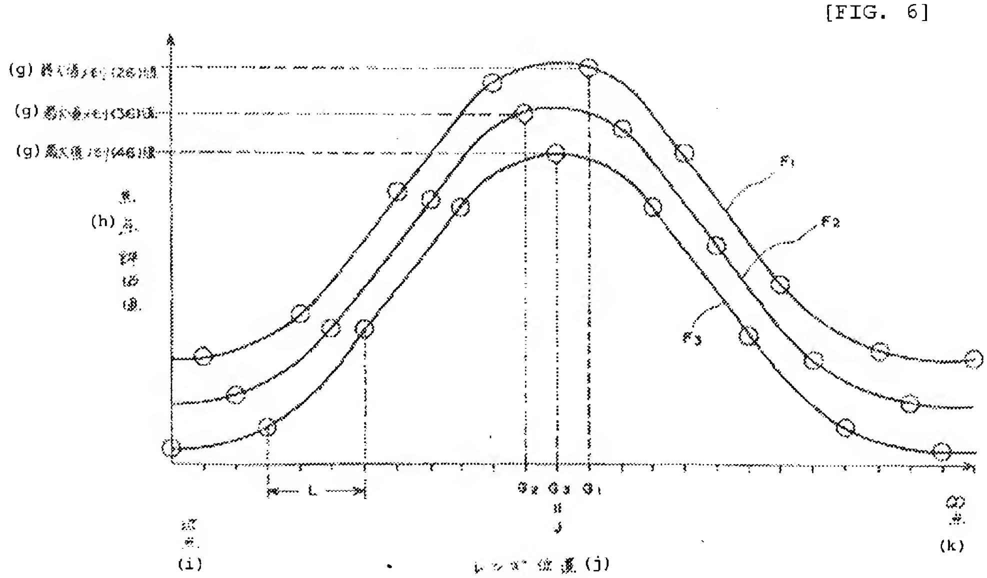
[FIG. 4]



[FIG. 5]



[FIG. 6]



Key: 4) imaging circuit; 5a) synchronizing separator; 5b) gate control; 5c) gate; 5e) detection; 5f) A/D converter; 5g) integrator; a) focus evaluation value; b) near point; c) focus point; d) lens position; e) 1 field; f) average luminance level; g) value in the

greatest value memory; h) focus evaluation value; i) near point; j) lens position; k) infinity point.